CONSTRAINED ADJUSTMENT GUIDELINES
Last Update: November 2004

INTRODUCTION

The following instructions, meant to be used only as a guide, provide a step-by-step approach for adjusting survey projects to the NAD 83. Occasionally, a project will have some special circumstances that require a deviation from the suggested procedure. These guidelines were originally developed for internal use at NGS. Some software or procedures may not be available to the public but any required programs are available and all procedures are applicable to anyone preparing a project for submission to NGS.

Read the guidelines thoroughly before beginning your project. There are some procedures which you may want to perform in an order differing from that arranged here (e.g. corrections to the B-file before the final adjustment). If you see any procedures consistently incorrect, notify Maralyn Vorhauer at maralyn.vorhauer@noaa.gov.

NOTE: 6/15/04- This update to the guidelines documents the procedures in place at the current time. Also, because the latest version of ADJUST allows the user to specify the type of vertical control to be used for control (adding an 'E' (ellipsoidal) or 'O' (orthometric) following the value of the height in the A-file), the procedures for running horizontal and vertical adjustments have been simplified. The changes are also reflected in this document.

Description of Terminology

The following terminology will be used throughout this document:

A-file - Adjustment constraint file
B-file - Data from field observation logs including equipment codes and station information file
D-file - Digital station description file
dfile - Doppler information file
G-file - Processed GPS vector data file
Serfile - Station specific 4-character identification and 4-digit serial numbers list
T-file – sometimes used to identify a B-file which only contains terrestrial observations
Bluebook – the document "Formats and Specifications of the National Geodetic Survey Data Base".

SECTION 1

GATHER MATERIAL FOR THE PROJECT

I. Necessary items for submission to NGS will include:

Project report
Approved Project Proposal
Project Sketch
Project Instructions or Contract Specifications
Final Station List
Station Visibility Diagrams
Final Observing Schedule
Observation Logs
Equipment Failure Logs (NGS Projects)
Loop Misclosures (optional)
Free Adjustment with Analysis
Free Adjustment with Accuracies
Constrained Horizontal Adjustment
Constrained Vertical Adjustment (NAVD 88 Heights)
Meteorological Instrument Comparison Logs (if specified)
Photographs of Views from Stations (if specified)
Photographs or Rubbings of Station Marks
COMPGB Output (Validation Program - B/G-files)
OBSDES Output (Validation Program - B/D-files)
OBSCHK Output (Validation Program - B/G-files)
CHKDESC Output (Validation Program - D-file)
NEWCHKOBS Output (Validation Program B-file, T-file)
ELLACC Output
BBACCUR Output
Digitized Data Files:
- Project Report
- Photographs (if required or desired)
- Raw Phase Data (R-files)
- Base Line Vectors (G-file)
- Project and Station Occupation Data(final B-file)
- Descriptions or Recovery Notes(D-file)
- Terrestrial Horizontal Observations(T-file)
- Differential Leveling Observations(L-file)

Abstracts and List of Directions (classical projects)
Distance reduction sheets (classical projects)

II. A project log can be useful in writing the project report. For example, list station names, azimuth marks, whether a station was described or recovered, and whether it was fixed, readjusted, or new. Note bench marks on the station list. Also note any unusual situations or procedures.

III. Note in the project report any problems mentioned in the field report, especially those which affect the adjustment or analysis. Review the output of the format checking programs and note any unresolved error messages from these listings in the project report. If you are checking this project for inclusion in the National Geodetic Survey Integrated Data Base (NGSIDB) without further processing, verify that the positions submitted as final have the correct adjusted position and height values, and that the files are free of format errors.

IV. For GPS projects, verify the Solution Coordinate Reference System Code in cc 52-53 of the Records in the G-file. The code represents the reference system of the position used to reduce the vectors. These codes are available in the Federal Geodetic Control Subcommittee document: *Input Formats and Specifications of the National Geodetic Survey Data Base.* This publication can be downloaded from the NGS Web page: www.ngs.noaa.gov

V. If you are working on a project in California or southern Alaska, determine the epoch the project requires for the final positions. Program HTDP can be used to update the observations and positions to the correct epoch.

SECTION 2

PRELIMINARY PROCESSING

Examine the B-file for obvious errors requiring correction. Verify that the organization abbreviation in cc 19-24 of the first record matches the organization which did the survey. New organization abbreviations can be requested from Burt.Smith@noaa.gov.

Perform the following series of checks:

I. Run COMPGB, NEWCHKOBS, and OBSCHK. Resolve error messages not related to *86* record codes and note the resolutions in the project report if appropriate. Ignore messages about *10*, *11*, *13*, and *90* records. Information in these records is not used in the adjustment process or loaded into the NGSIDB, but may be helpful in researching problems which arise during processing. Record any unresolved anomalies in the log. (*86* record codes will be added during the adjustment process).

NOTE: In NEWCHKOBS and OBSCHK, an error message is generated for a "0" antenna height. If the station is a CORS station, this message can be ignored. Other stations in the project must not have "0" antenna heights. This message is the only error message which need not be resolved in OBSCHK as error messages in this program prevent loading of the data in the NGSIDB.

II. Verify and change if necessary the 4-digit station serial numbers (SSN's) in your description file to match your B-file and G-file. Make sure the full station names in the D-file and *80* records of the B-file are correct and match (e.g. do not use 4 character IDs for station names in the Bluebook). Run OBSDES and CHKDESC and resolve error messages and inconsistencies.

III. In the NGS office, run desc_pos, NEIGHBOR, DISCREP and CHKDDESC (option I). Messages which are 'errors' **MUST** be corrected. Messages flagged as 'warnings' should be checked, and corrected if appropriate. Only change description codes flagged by DISCREP messages if you have verification that such a change is warranted.

NOTE: Programs NEIGHBOR and DISCREP require access to the database since they perform database comparisons. Program desc_pos is a Unix program, also not currently available for the PC.

NOTE: If excessive errors are found during the review of a project submitted to NGS by an outside agency, files will be returned to the agency responsible for the survey for corrections.

Rerun the format validity checking programs (part I. above) as needed to ensure changes do not generate new errors and just prior to submission of the project for NGSIDB loading.

SECTION 3

CHECK THE BLUE BOOK POSITIONS AGAINST
FILES AND LISTINGS OF PUBLISHED STATIONS

I. Determine which horizontal and vertical datums will control the adjustment and note them in the project report. Currently only NAD83 and NAVD88 are allowed datums; the use of any other datums must be cleared with the Director of the agency.

II. In the NGS office, retrieve a file of published positions in B-file format from the NGSIDB (or, in the field, pull datasheets from the NGS web page). In the office, use program CLUSTER to compare the *80* records in your B-file observation deck with those in the file of published positions. In the office check the status of FBN's, state readjustments, and other possible projects in progress in the area for conflicts.

III. If the B-file does not already have *86* records run MAKE86, creating a new output B-file that will be used as input to the adjustments and program GEOID. Run the current GEOID program to add geoid heights to the B-file *86* records.

IV. Research orthometric and ellipsoid heights. If adequate NAVD 88 datum vertical control exists, use only that control in the vertical (orthometric height) adjustment. If insufficient control exists on the NAVD 88 datum, determine whether there are NGVD 29 control points that can be transformed to NAVD 88 using VERTCON. (The *86* record for the transformed stations should have a "D" in the elevation code field.) Verify elevation codes in the *86* records for all stations.

If the field crew leveled from a known bench mark, the leveled elevation can be used for control subject to consistency with other bench mark heights used in the project. Be sure to include a paragraph in your project report discussing any leveling used. The *86* record should have an elevation code of "L" or "T" for stations with leveling. ADJUST does not use *45* or *47* records in processing although data on those records is loaded in the NGSIDB. To use this information in the adjustment, code a "CH" record in the A-file. Leveling done to be included in the NGSIDB should be discussed with Davey Crockett or Kathy Koepsell (davey.crockett@noaa.gov or kathy.koepsell@noaa.gov). If possible, compute positions for any bench marks used during the project.

V. Make certain that station names match the current naming conventions in the B-file *80* records, i.e. remove dates and agency abbreviations. If a name change from the published name is desirable, note this in your project report. Sort the *80* records alphabetically (optional). Verify station order-and-type codes. For old stations, the order-and-type should be what the project requires, not what is published. If the station is used as control, and fits well in the adjustment, the NGSIDB will be updated with the new order-and-type code. If the station does not fit, it should not be used as control. Document in your project report any stations published as a lower order than your job which were used for control. For stations with order-and-type code 47, blank out the orthometric height in the *86* record in the final B-file.

VI. If there are any classical observations in your B-file, and if you have not yet run MODBB, run it now.
NOTE: Make certain the elevations in the *86* records are correct, since they will affect the distance reductions computed by MODBB. (See Appendix E).

VII. If you have any classical observations in your project, run DEFLEC on your observation file; the deflection values will be added on *85* records. This deflection will compute the ETA value for the LaPlace correction if you have astronomic azimuths. The deflection correction is generally negligible for other types of observations, e.g. directions and distances, but can be significant for some; therefore DEFLEC should be run on all terrestrial observation files even if no astronomic azimuths are present.

SECTION 4

ADJUST THE PROJECT WITH MINIMUM CONSTRAINTS

I. Run ADJUST with minimum constraints. Constrain only one station position per component. Multiple components arise in projects which have disjoint networks combined in one file. For classical projects, add inversed azimuths and distances to the A-file for solvability where necessary.

A) If there are GPS observations and the project contains at least 2 published ellipsoid heights, run a 3D adjustment, holding one adjusted position, latitude and longitude, and one ellipsoid height fixed per component. NOTE: If no ellipsoid height control exists, constrain one bench mark elevation.

B) If there are no GPS observations, run a 2D adjustment.

II. Resolve large residuals by checking for blunders. Reject, only as a last resort, those redundant observations which have a high residual (or normalized residual for terrestrial observations). Don't leave a station no-check by rejecting observations to it. For NGS UNIX system users, use PLOTRES to plot residuals for GPS projects as an aid in analysis.

The vector standard errors in all GPS projects, lower than B-order, must be scaled. The standard errors assigned to GPS vectors are generally overly optimistic. Scaling the standard errors (resulting in a variance of unit weight of 1.0) makes different projects reasonably consistent with each other. This is done by running MODGEE which scales the standard errors of the vectors in the G-file. Use a scale factor equal to the standard deviation of unit weight of the free adjustment after all rejections are made.

NOTE: Never scale a GPS project of B-order accuracy or better.

If classical observations are involved, save the adjusted positions for the vertical run.

III. Classical Observation Adjustments -Before beginning constrained runs, be sure the inversed azimuths and distances are removed from the A-file.

NOTE: Run all adjustments in mode 3 (normalized residuals). This is done by coding the MM record in the A-file as MM3. This mode computes residuals scaled relative to the standard deviation of the residual (normalized residuals). For classical observations, outliers are more easily identified from the normalized residuals.

SECTION 5

RUN THE CONSTRAINED HORIZONTAL ADJUSTMENT

I. If there are GPS observations run ADJUST in 3D. Hold all previously published positions and ellipsoid heights. For network project, minimum of 2 ellipsoid heights are needed to adjust ellipsoid heights in your project. (Otherwise, constrain one orthometric height. No ellipsoid height adjustment will be performed.) Compare the results with the free adjustment. Were there any large shifts in the positions?

II. If there are no GPS observations, run ADJUST in 2D and mode 3 holding the positions of all previously published stations. Be sure the elevations are correct.
NOTE: For classical projects, you should run the vertical adjustment first. If you run the horizontally constrained adjustment first, be sure the elevations do not change significantly from those used in this run. Incorrect elevations can cause problems with distance observations (see Appendix E).

III. Large residuals in this run, which were not in the free adjustment, are the result of problems with the constraints. Do not reject any observations due to constraints. Verify that the control used is correct and on a consistent datum. For observations with large residuals, check for misidentifications. If no problems can be identified, determine whether you should readjust some of the existing positions. Consider the requirements of your project. If a station you are readjusting is well positioned in your project, readjust with only the GPS vectors in your project.

Save the adjusted positions from this run. Discuss all readjusted stations in your project report.

SECTION 6

RUN THE MINIMALLY AND FULLY CONSTRAINED VERTICAL ADJUSTMENTS

If you have good control on the NAVD 88 datum, use only that control. If insufficient control exists on the NAVD 88 datum, look for NGVD 29 elevations, and transform them to the NAVD 88 datum using the transformation program VERTCON. Select bench marks first. If, upon examination of the results of the first vertically constrained adjustment, it appears that GPS-derived elevations fit the project, add them to your list of constraints. Only if further control is still needed, use elevations computed from vertical angles.

I. For GPS projects, run ADJUST with minimum constraints. Constrain one previously adjusted elevation and one NAD 83 adjusted position to get a vertically free adjustment.

II. For GPS projects, run ADJUST with vertical constraints. Constrain all previously adjusted elevations as specified above, and one NAD 83 adjusted position.

Investigate observations with large residuals, and stations whose elevation shifted significantly between the free and vertically constrained adjustments. The same rule applies as in the horizontal constrained adjustment: no rejections due to constraints. Look for inconsistent shifts as opposed to areas where the shifts, even high shifts, are consistent. Likewise, look at the geoid heights to see if they are consistent. You may want to plot these shifts on a sketch to facilitate analysis. For inconsistent shifts, look at the recovery notes to see if any movement is indicated, or if the wrong mark was observed, such as the underground mark instead of the surface mark. If no cause for the shift can be found, the elevation may need readjusting. Free the elevations in question and rerun as a test. Note the differences between the published elevations and the readjusted elevations obtained from the vertically constrained test adjustment. Consider the requirements of the project before deciding whether to readjust.

III. When the constrained vertical adjustment is complete, for GPS projects, use program ELEVUP to combine the Blue Book decks from the vertically and horizontally constrained adjustments so that the final B-file contains the positions and ellipsoid heights from the horizontally constrained adjustment and the elevations and geoid heights from the vertically constrained adjustment.

IV. For classical projects, use the adjusted positions from the 2D free adjustment and run ADJUST in 1D. Hold previously adjusted elevations as specified above. (The adjustment from Section Four will serve as the vertical free adjustment.)

For classical projects, if there are any significant changes in the elevations between preliminary and adjusted values, then you need to re-reduce the distances to mark-to-mark. To do so, run MODBB with the original unreduced distances and the adjusted elevations. Then, rerun the 2D free adjustment and the 1D adjustment. See Appendix E for tables demonstrating the impact of the elevation change on the distance reduction.

SECTION 7

RUN FINAL FREE ADJUSTMENT WITH ACCURACIES

Run a final adjustment with minimal constraints as in SECTION 4. Accuracies will be produced by ADJUST if you include QQ records in your A-file. Use program QQRECORD to generate the QQ records for your A-file. For multiple-order projects, you will have to edit the order on the QQ records in your A-file. For this adjustment, input the B-file created by the horizontal constrained adjustment.

If your project is A- or B-order, the standard errors in the G-file were not scaled. In order to compute the accuracies correctly, the G-file standard errors must be treated as scaled. To do this, change cc4 in the MM record of the A-file to a "Y," the option to "scale the standard deviations with a-posteriori standard deviation". The value ADJUST will use for the scaling is the "STD. DEV. OF UNIT WEIGHT" shown on the summary residual statistics page. Note this value in your adjustment report.

Run program BBACCUR2 using the output of this adjustment to create a formatted listing of all accuracies to attach to your project. Check both sets of accuracy estimates, the internal and external, to see that the standards of the project are met. If internal accuracies do not meet the standards, then perhaps the specifications were not adhered to. Verify the field procedures. If internal accuracies look good, but external accuracies are low, then perhaps a station or stations need to be readjusted. Do a test constrained adjustment where the stations associated with low accuracies are freed up. Then do a test free adjustment with accuracies to see if the standards are now met. If the second adjustment is significantly better, consider the project requirements to determine which adjustment should be accepted. Discuss in your report any accuracies which still do not meet the project's specifications and possible reasons.

Run program ELLACC again using the output of this final free adjustment with accuracies to classify ellipsoid height order and class. From the listing, select the predominant classification and add it to all *86* records in columns 54-55. Submit the printout with your project. Confirm that the correct ellipsoid height code is used in column 53 (almost always 'A') and the correct datum in column 56 (almost always A); add these items as needed.

SECTION 8

POST ADJUSTMENT PREPARATION FOR SUBMISSION

I. Prepare the B-file for submission. Most of these items will have been completed before the final adjustment, but should be double-checked at this time. Use the checklist in Appendix C.

A. Identify horizontal and vertical no-check stations in the project. In the *80* record, change cc 5 to 'N' for vertical no-checks, cc 6 to 'N' for horizontal no-checks. (Elevation codes M and P will default to no-check.) A new station is no-check when all of its observations get a zero residual in the constrained adjustment. There are instances when the 'N' in the observational summary is not an accurate means of identifying no-check stations:

1. In a dangling traverse, a station can have 2 directions from, 2 to, and 2 distances and still be no-check.
2. In a GPS project, a station determined by only one vector might be correlated with other vectors resulting in a non-zero residual. The observational summary will show an 'N'. Document these cases in your report. NGS will determine which stations will be saved in the NGSIDB as no-check.

B. Verify that station names conform to the new naming conventions, i.e., no dates or agency abbreviations.

C. Check order-and-type codes. Determinations of upgrades or downgrades to order-and-type will be based on both accuracy achieved and, for classical work, geometric strength of the ties of the new project to the network. Carefully document all changes.

D. In order to load any leveling observations in the B-file *80* series records must exist for both ends of the line, even if one of them cannot be positioned horizontally. If neither standpoint nor forepoint is positioned, remove the leveling observation from the deck. If one end of the line is unpositioned, add a *82* record in your deck for that point, giving it an SSN as if it were a peripheral for the standpoint.

E. Check all elevation codes and values. Remove elevations (including zero elevations) and elevation codes from the *86* records of landmark stations if there are no distance observations involving the landmarks. Order-and-type 47 should not have an elevation. If a distance is involved the order-and-type should be 43.

F. Add the PID to the recovery notes for existing stations in the D-file. (See the datasheet for the PID.)

G. Sort the *80* records alphabetically.(optional)

H. Rerun the checking programs. If you have a file (or database file) of existing adjusted positions, run CLUSTER on the final B-file comparing these positions. Program DIFLATLON can also be used to compare both positions and heights.

I. Verify state abbreviations.

J. The first record in the B-file must contain the initials of the observing organization (left-justified). This organization must be listed in ‘Annex C’ of the Bluebook: http://www.ngs.noaa.gov/FGCS/BlueBook/annexc/annexc.index.html. If not, request an addition to the contributor table as noted previously.

II. Write the project report. See Annex K and/or L of the Bluebook for instructions.

III. NGS office - copy the final files to the Unix system directory /home/maralyn/Projects. The program maralyn.go will prompt you for the files to be copied. The following naming convention should be used:

gnumber.filetype.comment.

where number is the GTZ° or GPS° of your project, file type is the kind of file (B-file, G-file, and D-file) and comment refers to any other necessary identifier (e.g. part1, part2, and main, supplemental). The B-file should contain the adjusted positions and elevations from your constrained runs. Submit all items on the checklist in SECTION 1 to your supervisor.

APPENDIX A

Processing Programs

ADJUST - required

Performs a least-squares adjustment in up to 3 dimensions of horizontal, vertical angle, GPS, and Doppler data.

Input – B-file (blue book observations, positions), A-file (ADJUST instruction parameters), G-file (GPS vectors), dfile (doppler observations)

Output - adjustment output (messages, results, statistics)
updated B-file (positions updated with adjusted values), if requested

Programmer - Jim Mosier.

ADJUSTA - in-house use only, requires data base access

Performs a station adjustment using IDB observations at a specified station.

Programmer - Craig Larrimore.

AFILELK

Lists all fixed positions and elevations, along with station name, for inclusion in the project report.

Input – A-file, B-file

Output - formatted listing of constraints

Programmer - Ed Carlson.

BBACCUR2 - required

Generates a file of single line accuracies from an ADJUST output file. Produces an efficient listing for use with the project report.

Input - adjust output from free adjustment with accuracies

Output - formatted listing of accuracies

Programmer - Bill Waickman.

BBLOAD.DESCHK - in-house use only

Compares observation deck and unified description deck for inconsistent SSN's, station names, and positions. Optional.

Programmer - Craig Larrimore.

BIGADJUST

Same as ADJUST except the array size has been increased to handle state adjustments. Has extended file record formats to accommodate jobs with more than 10,000 stations. This program is not available through the menu.

Programmer - Jim Mosier.

BIGED - in-house use only

Interactive program to edit large Blue Book data files.

Programmer - Jim Mosier.

CHBBOOK - used with COMBINE

For a B-file (and G-file) with different SSN's assigned to stations with duplicate names, changes the SSN's to be the same. Duplicate position records must be deleted by the processor.

Programmer - Ed Carlson.

CHKDDESC - required

Validity checks D-file format description file.

Input - D-file format description file

Output - listing of format error messages

Programmer - Janet Irwin.

CLUSTER

Compares *80* records between decks, e.g. a B-file observational deck and a Database retrieval file or another B-file. .

*Input - 2 B-files or files of *80* format records*

Output - listing showing the positional differences between the same stations in the 2 files, file of common stations

Programmer - Ed Carlson.

COMBINE

Combines two B-files and/or G-files together. Input old or new format B-files. The output is in new B-file format.

Programmer - Ed Carlson.

COMP80 - in-house use only

Computes preliminary NAD 83 positions for any blank *80* records using a direction and a distance. To save the inverse computations, run in demand.

No documentation available.

Programmer - Steve Frakes.

COMPGB - required

Performs validity checks on G-file and B-file for consistency and compatibility.

Input – G-file B-file, serfil

Output - listing of inconsistencies between the 2 files

Programmers/Contacts - Mary Oleson

CRAFILE – in-house use only, not available for PC

An interactive program which creates or modifies an existing A-file. The program will also update the observation deck with the values from the A-file.

Input - Interactive or **CLUSTER** *output(. "common" file)*

Output – A-file, optional *B-file*

Programmer - Ed Carlson.

CREFIL - in-house use only, requires data base access

Retrieves horizontal position and observation data from the database and puts it in one of several useable formats, e.g. Blue Book.

Programmer - Craig Larrimore.

DEFLEC

Computes the ETA value necessary for making LaPlace corrections to astronomic azimuths.

Input – B-file

Output - updated B-file

Programmer - Dennis Milbert.

DIFLATLON

Computes the differences between stations with the same SSN in two different Blue Book decks, e.g. free adjustment results versus constrained. Lists the difference in latitude, longitude, and elevation as well as the shift in meters.

*Input - 2 B-files or files of *80* format records*

Output - listing of differences between the same stations in the 2 files

Programmer - Ed Carlson.

DISCREP - in-house use only, requires data base access

Validity checks d-file format description files against the NGSIDB.

Input - D-file format description file

Output - error list file

Programmer - Janet Irwin.

ELEVUP – required for GPS projects.

Combines *80* and *86* records from constrained horizontal and constrained vertical blue book decks to produce a final deck containing the final adjusted positions and heights.

Input - 2 B-files, one with adjusted elevations with geoid heights and one with adjusted positions and adjusted ellipsoid heights

Output - 1 updated B-file containing all adjusted values

Programmers - Bill Waickman.

ELLACC - required

For projects in which ellipsoid heights were adjusted, uses the final free adjustment with accuracies output run and computes the order and type of the ellipsoid heights for the project.

Input - final free adjustment output

Output - listing of totals of ellipsoid height accuracies computed

Programmer - Bill Waickman.

FORWARD

Computes the geodetic position given the geodetic azimuth and distance from a known position. (Also FORWRD3D, for 3-dimensional marks.)

Input – Interactive

Output - coordinate

Programmer - Steve Frakes.

GEOID - required

Updates *86* records with Geoid heights from NGS' latest geoid model.

Input – B-file

Output - updated B-file

Programmers - Dru Smith/Dan Roman

GPPCGP

Computes state plane coordinates from geodetic positions (or vice versa) on the NAD 27 datum.

Input - Interactive or file of positions or coordinates

Output - file of coordinates or positions

Programmer - Ed Carlson.

HTDP

Predicts and updates coordinates and/or observations to a user-specified date to facilitate adjusting survey data to particular epochs in crustal motion areas.

Input –Interactive or B-file, G-file

Output – updated coordinates or B-file, G-file

Programmer - Richard Snay.

IDB_RET - in-house use only, requires data base access

Retrieves positions, elevations, observations, and descriptive data from the database. For retrievals of large areas see Craig Larrimore.

Programmer - Craig Larrimore.

INVERSE

Computes the geodetic azimuth and distance between two stations given their geodetic positions. (Also, INVERS3D, which computes distance for 3-dimensional marks.)

Input – Interactive

Output - azimuth and distance

Programmer - Steve Frakes.

LOCUS

Identifies the stations in a file which fall within a user defined radius of a specified central location. Can be used for 3- or 4-digit B-files.

Programmer - Steve Frakes.

MAKE86 - required

Creates *86* records in blue book observations files. Will not remove existing *86* records. Uses orthometric height from the *80* record if present.

Input –B-file

Output - updated B-file

Programmer - Ed Carlson.

MARALYN.GO - in-house use only

Transfers the final decks to Maralyn Vorhauer's project directory on the Unix system.

No documentation necessary.

Programmer - Ed Carlson.

MODBB - required for terrestrial surveys

Computes standard error and reduces to mark-to-mark zenith distances, distances, and position records, both 3- and 4-digit SSN's.

Input – B-file

Output - updated B-file

Programmer - Jim Mosier.

MODGEE - required for projects lower than B-order

Scales standard errors of observations in Blue Book GPS observation decks.

Input – G-file, scale factor

Output - updated G-file

Programmer - Mary Oleson.

NADCON

Compute positional data (latitudes and longitudes) from NAD 27 to NAD 83 and vice versa. The latest version is continually being updated to include those states where high accuracy GPS surveys have been used for state readjustments.

*Input - Interactive or file of blue book format *80* records*

*Output - file of updated *80* records*

Contacts - Cindy Craig/Dave Doyle.

NEIGHBOR - in-house use only, requires data base access

Validity checks D-file format description files against the NGSIDB.

Input - D-file format description file

Output - output file of neighboring (clustered) stations

Programmer - Janet Irwin

NEWCHKOB - required

Validity checks Blue Book observation deck.

Input – B-file

Output - listing of format error messages

Programmer - Jim Mosier.

OBSCHK - required

Validity checks a B-file, and will perform some checks on the G-file if one exists.

Input – B-file, G-file

Output - listing of validity errors

Programmer - Jim Mosier.

OBSDES - required

Validity checks a Blue Book observation deck against a unified or d-file format description file

Input - unified or D-file format description file, B-file

Output - listing of inconsistencies

Programmer - Jim Mosier.

PLOTRES - in-house Unix system use only

Plots residuals to facilitate analysis of GPS adjustment results. *Input - adjustment output file*

Output - graphic plot showing horizontal and/or vertical residuals

Programmer - Ed Carlson

PLTPRJ – in-house use only

To plot observation decks with 3-, 4-, or 5-digit SSN's. PLTPRJ4 has an option to plot elevation differences of constrained stations using the B-files and the A-file for the vertical adjustment.

Programmer - Jim Mosier.

PROMPTER

Creates *80* records by prompting the user for each value.

Input - Interactive

*Output - file of blue book format *80* records*

Programmer - Bill Waickman.

QQRECORD

Generates and adds QQ records to an AFILE using a Blue Book or GFILE. Only one QQ record will be generated over each line of observation.

Input – A-file, B-file or G-file

Output - updated A-file

Programmer - Bill Waickman.

SHIFTVPLOT - in-house use only

Computes shifts in coordinates between 2 Blue Book files. Output is a file of shifts for input into program VPLOT.

Documentation not available.

Programmer - Bill Waickman.

SPCS83

Computes state plane coordinates from geodetic positions (or vice versa) on the NAD 83 datum. (Also SPCS83EH, showing ellipsoid heights).

Input - Interactive, or file of positions or coordinates

Output - file of updated coordinates or positions

Programmer - Ed Carlson.

UTMS

Computes UTM coordinates from geodetic positions and vice verse for NAD 27 and NAD 83.

Input - Interactive or file of coordinates or positions

Output - file of updated positions or coordinates

Programmer - Ed Carlson.

VERTCON

Transforms NGVD 29 elevations to NAVD 88

Programmer - Bill Waickman.

VPLOT - in-house use only

Plots shifts between positions in 2 B-files on the laser printer. Uses as input the shift file from program SHIFTVPLOT.

Documentation not available.

Programmer - Bill Waickman.

The following programs are for in-house use only, as they apply to backlogged jobs whose descriptions are in a different format.

CHKDESC

Validity checks unified description file.

Input - unified description file

Output - listing of format error messages

Programmer - Janet Irwin.

CONVRT

Converts a travdeck or vertdeck into Blue Book format.

Programmer - Ed Carlson.

DESCSRT

Sorts a description file alphabetically.

Input - unified description file

Output - updated unified description file

Programmer - Ed Carlson.

DESCUP

Changes SSN's in description files to match the Blue Book deck numbers (searches by name).

Input - unified description file, B-file

Output - updated unified description file

Programmer - Ed Carlson.

NAMES

Converts a NUMNAM deck into a travdeck.

Programmer - Ed Carlson.

OLDU2NEW

Translates unified description files into new d-file format files.

Input - unified description file

output - D-file format description file

Programmmer - Janet Irwin

TONEW

Converts 3-digit SSN bbook to 4-digit format.

Input - 3-digit B-file

Output - 4-digit B-file

Programmer - Gloria Edwards.

APPENDIX B

Constrained Adjustments Processing Outline

I. Gather Source Material

A. B-file, G-file, D-file, T-file
B. sketches, reports, logs
C. verify Solution Coordinate System Reference System Code, cc 52-53 of B-records in G-file

II. Preliminary Processing

A. Run checking programs
   1. COMPGB
   2. CHKOBS
   3. OBSCHK
B. Verify codes, e.g. elevation code, order and type, no-check code
C. Run HTDP if needed
D. Verify descriptions using WDDPROC

III. Identify Control

A. Choose horizontal and vertical datums, and epoch as needed
B. Retrieve horizontal positional control
C. Run MAKE86 - create *86* height records
D. Run GEOID – add geoid heights to *86* records
E. Retrieve orthometric height control.
F. Retrieve ellipsoid height control.
G. Verify station designations against NGS IDB designations.
H. If classical observations
   1. Run MODBB
   2. Run DEFLEC

IV. Adjust with Minimum Constraints

A. Create A-file
   1. Constrain 1 position per component
   2. For GPS, constrain 1 ellipsoid height per component. (Note that the height in the A-file will have a code of ‘E’.)
   3. If insufficient ellipsoid height control exists, constrain 1 orthometric height per vertical component
B. Run ADJUST
C. Resolve singularities, Misclosures
D. If GPS observations, run residual plotting program
   Resolve large residuals
   1. For A order: 2 cm
      For B order: 3 cm
      For 1st order: 5 cm
   2. correct blunders
   3. reject badly fitting observations - don’t create no-checks
E. Run MODGEE for first order projects.

V. Adjust Horizontal Constrained

A. Create A-file
   1. Constrain all published positions
   2. For GPS, constrain all published ellipsoid heights (at least 2)
   3. If insufficient ellipsoid height control, constrain 1 orthometric height per vertical component

B. Run ADJUST
   1. Input B-file created by free adjustment

C. Determine if any stations should be readjusted based on large residuals

D. Rerun ADJUST until satisfactory

E. If adjusting classical data, run vertical constrained adjustment before horizontal constrained

VI. Adjust Vertical Free

A. Create vertical free A-file
   1. Constrain 1 position for each component
   2. Constrain one published orthometric (bench mark) height per component
   3. Note: if there are no published ellipsoid heights, the free adjustment also serves as the free vertical adjustment.

B. Input: B-file from horizontal constrained adjustment

C. Run ADJUST-Resolve large residuals

VII. Adjust Vertical Constrained

A. Create vertical constrained A-file
   1. Constrain 1 position per component
   2. Constrain all published orthometric (bench mark) heights (at least 3)

B. Run ADJUST
   Determine if any stations should be readjusted
      a. Large residuals
      b. Inconsistent height shifts between results of vertical free and vertical constrained adjustments

C. Rerun ADJUST until satisfactory

VII. Adjust with Minimum Constraints Computing Accuracies

A. Create A-file
   1. Use A-file from original free adjustment
   2. Run QQRECORD to create QQ records
   3. Modify MM record for projects with unscaled G-file.

B. Run ADJUST
   1. Input B-file from horizontal constrained adjustment

C. Look at internal accuracies to measure internal consistency

D. Look at external accuracies to measure fit to control used
   1. Run BBACCUR to created formatted list of accuracies
   2. Should some stations be freed to meet accuracy requirements?
   3. If yes, return to step V.

E. Run ELLACC to compute ellipsoid height accuracies

VIII. Post Processing

A. Run ELEVUP
   1. Input B-files from final horizontal and vertical constrained adjustments
   2. Output final B-file containing adjusted positions, orthometric heights, and ellipsoid heights
   3. Edit B-file to add ellipsoid height accuracy to cc54-55 of *86* records

B. Make any other corrections necessary to B-file
   1. Rerun checking programs on final B-file
   2. Confirm all codes and values - run CLUSTER

C. Write adjustment report
   1. 1st 2 pages are NOAA forms 76-161 and 76-162 included with Appendix D or equivalent information summarizing project
   2. In text discuss
      a. Purpose of project
      b. Notes on field problems
      c. Results of free and constrained adjustments - with list of constraints
      d. Rejections
      e. Readjusted positions, heights
      f. Accuracy results
      g. Problems resulting from checking programs
      p. Processing of description file

D. Submit
   1. Final validity checking programs
   2. Final adjustments
   3. Copies of B-file, G-file, D-file
   4. Sketches or plots
   5. Signed report

APPENDIX C

B-File Checklist

Names follow current conventions.

Order-and-type codes, state codes, and elevation codes are correct.

80 or *82* records exist for both ends of leveling observations.

Horizontal and vertical no-checks have been identified with 'N' in cc 6 and cc 5 respectively in the *80* record.

80 records are sorted alphabetically (optional).

Blank out elevation field for stations whose OT is 47. (this applies to a classical B-file only).

Checking programs have been rerun.

The first B-file record contains the observing organization's initials.

Positions and heights are correct (match final submitted adjustments).

APPENDIX D

Project Report Checklist

Title Pages - NOAA Forms 76-161 and 76-162 (or equivalent information)

Project statistics

Order and type of project, datums, purpose

Problems encountered in the field and resolution

Checking program results

Geoid model used

Discussion of results of free, horizontally constrained, and vertically constrained adjustments

Discussion of procedural changes, solutions to unusual problems

List of horizontal and vertical fixed control

List of no-check stations

List of accuracies which fall below expectations, and discussion

Discussion of any readjusted stations

Discussion of overall results

Notes on description file - missing descriptions, etc.

Finally, verify numerical statistics on first pages of report

NOAA Form 76-161

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Adm.

COMPUTATION
OF
HORIZONTAL CONTROL

NAD 83 ( )

NAVD 88

STATE

LOCALITY

.....
_____

Year of Observation:
Year of Computation:
_____

Chief of Party_____

Observer_____

Computer_____

NOAA Form 76-162

U.S. DEPARTMENT OF COMMERCE
National Oceanic & Atmospheric Administration
National Ocean Service
National Geodetic Survey

REPORT OF HORIZONTAL CONTROL COMPUTATIONS

****

State:

Classification:

Horizontal Datum: NAD 83 ( ) Vertical Datum: NAVD 88

Locality:

Accession Number:

Date of Field Work: Chief of Party:

*******OFFICE COMPUTATION*******

Date of Computation:

Number of Stations in project:

New:	=	Main Scheme:	=
Old:		Supplemental:	=
Fixed:	=	Non-monumented:	=
Readjusted:	=	Temporary:	=
Total	=	Total	=

Free adjustment variance of unit weight (σ^2_o): =
Constrained adjustment variance of unit weight (σ^2_1) =
Ratio: σ^2_1/σ^2_o =

_____
Geodesist in charge of work

_____
Chief of Branch

APPENDIX E
Reduction of Slope Distances to Mark-to-Mark

The following tables show the changes in the reduced distances based on elevation changes of one meter and ten meters. As you can see, the line length and the t-o are important factors in determining how much a reduced distance is going to change.

For a 100.000 meter line:

		Delta H 1m	Delta H 10m
	0m	.000	.000
	1m	.010	.100
	2m	.020	.200
	3m	.030	.301
	4m	.040	.401
t-o	5m	.050	.502
	6m	.060	.603
	7m	.070	.704
	8m	.080	.806
	9m	.090	.908
	10m	.100	1.010

For a 500.000 meter line:

		Delta H 1m	Delta H 10m
	0m	.000	.000
	1m	.002	.020
	2m	.004	.040
	3m	.006	.060
	4m	.008	.080
t-o	5m	.010	.100
	6m	.012	.120
	7m	.014	.140
	8m	.016	.160
	9m	.018	.180
	10m	.020	.200

For a 1000.000 meter line:

		Delta H 1m	Delta H 10m
	0m	.000	.000
	1m	.001	.010
	2m	.002	.020
	3m	.003	.030
	4m	.004	.040
t-o	5m	.005	.050
	6m	.006	.060
	7m	.007	.070
	8m	.008	.080
	9m	.009	.090
	10m	.010	.100

For a 5000.000 meter line:

		Delta H 1m	Delta H 10m
	0m	.000	.000
	1m	.000	.002
	2m	.000	.004
	3m	.000	.006
	4m	.001	.008
t-o	5m	.001	.010
	6m	.001	.012
	7m	.001	.014
	8m	.002	.016
	9m	.002	.018
	10m	.002	.020

APPENDIX F
UPDATES

September 2000:

Section 7, step added to process ADJUST using a-posteriori standard deviation of unit weight for A- and B-order projects to assure the accuracies are computed correctly.

Input blue book filename changed from *final.bbk* to *cons1.bbk*.

Add Solution Coordinate Reference System Codes 18-20 to Section One.

July 2002:

Recommended filenames removed since they are inconsistent with other documentation and therefore confusing.

Appendix describing description processing removed. These procedures are no longer used since new description formats have been in place. Refer to instructions which come with WDDPROC software.

Add Solution Coordinate Reference System Codes 21 and 22 to Section One.

February 2003

Remove references to OBSDESED since program is obsolete.

Added information to Appendix A identifying which programs are appropriate for in-house use, and which programs were required for project submission.

Update Appendix A, Adjustment Processing Programs.

November 2004

Changes in procedures resulting from update to ADJUST to identify ellipsoid height constraints.

Changes to text to clarify procedures and other instructions.

New contact for guidelines.

Refer to Bluebook for orbit codes.

Refer to Bluebook for detailed project report instructions.